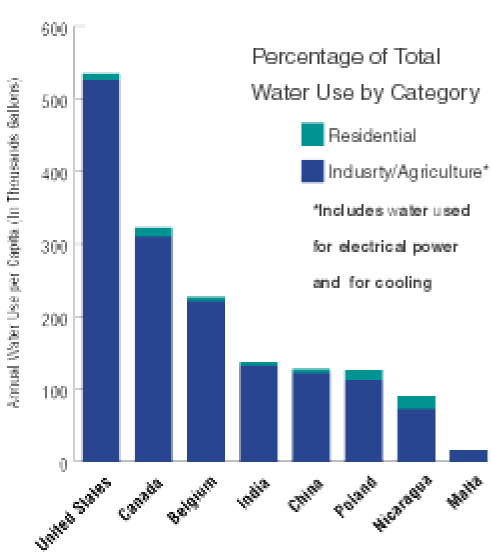
Safe Water Delivered Safely

You may know how important fresh water is to our diet, but did you ever think about how much water we consume every day? Americans and Canadians use more water than any other country, even those that are as equally developed. In fact, a typical family of four uses about 350 gallons per day at home for drinking, bathing, clothes and food washing, garden sprinkling, etc. Fortunately, Americans and Canadians enjoy some of the cleanest and safest drinking water in the world.

In other parts of the world, microorganisms that cause life-threatening waterborne diseases such as cholera, typhoid and dysentery often find their way into water supply systems. Diseases associated with dirty water kill more than 25,000 people per day -- more than 9 million each year -- around the world, according to the World Health Organization. Since 1908, however, when chlorine was first used in New Jersey to purify water, such epidemic diseases have been virtually wiped out in the U.S. and Canada.

While tap water that meets federal and state standards is generally safe to drink, there are still threats to water quality and quantity. In fact, the ability to regularly deliver safe water is a constant challenge to water suppliers. This publication will detail some of the myriad problems water distribution officials in the U.S. and Canada face every day, from corroding drinking water pipelines to the threat of waterborne diseases -- and how they can fix them.

Water Use in Different Countries



This document will first review the types of water pipelines used throughout the U.S. and Canada, the types of structural problems some of these pipes experience and the costs which are incurred due to these structural problems. Because pipeline structural problems can lead to contamination, this document will also discuss the increased threat of waterborne diseases. Finally, because chlorine chemistry plays a major role in safely delivering water to homes, businesses and schools -- through both disinfection and piping material -- this paper will show how pipelines made from chlorine-based vinyl plastic are part of the solution to these water-transport challenges.

Costly Pipe Failures Increase Risks

Ductile iron, vinyl and reinforced concrete represent the bulk of pipelines currently being used in the U.S. and Canada to deliver safe drinking water. However, cast iron and ductile iron distribution pipes are the most susceptible to corrosion and breakage. In fact, each year, thousands of water lines are removed for replacement -- most suffering from severe deterioration caused by corrosion.

Corroding iron, usually thought of in terms of rust, may take many forms. In the case of buried iron pipe for drinking water and sewage, the corroded material is a hard, graphitic substance which temporarily maintains the shape of the pipe wall and looks like iron, but provides

virtually no strength. Later, the material can form pits, which, in some cases, penetrate the wall and cause leaks. This type of corrosion contributes to water loss, pipe breakage and potential water contamination.

Changes in soil texture, temperature, moisture, oxygen, chemical make-up, organic material and bacteria are common factors that can contribute to corrosion and eventually cause pipe failure. The soil environment itself is a prime cause of iron pipe failures. Officials from Florida to Ontario have reported that ground conditions weaken aging pipelines.

Drought periods followed by heavy rain can cause ground conditions to become unstable, causing corrosion-embrittled pipelines to fracture and break. This can ultimately lead to severe water leakage. The resulting effects include street cave-ins, sinkholes and potholes -- not to mention wasted water. A single pipe leaking just one gallon of water per minute, for example, equals more than 500,000 gallons of water loss each year.

Common Causes of Main Breaks

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On the other temperature extreme, cold temperatures frequently drive frost deeper into the ground, causing more rigid water pipes to break. In fact, during the winter of 1995, Scarborough, a suburb of Toronto, experienced more than 160 breaks in one month alone -- about one break every four hours for 31 consecutive days. To remedy the challenges caused by aggressive soil conditions, officials install secondary protection inside metallic pipes, such as a coating, plastic sleeve or a cathodic screen. This added protection also increases the overall price of metallic pipe installation.

These problems are ever-present, costly and health-threatening. According to a recent survey conducted by the Canadian National Research

Council, cast iron pipes are rupturing at a rate of 35.9 breaks for every 100 kilometers of pipe in service. And newer ductile iron pipes are averaging about 9.5 breaks per 100 kilometers. These numbers are significant because they translate into over 200,000 breaks every year in the U.S. and Canada.

In terms of cost, taxpayers in Canada spend an average of $82 million every year to repair broken water mains -- an estimated $2,500 in repair costs alone for each pipe failure. And the Federation of Canadian Municipalities estimates that they lose about $650 million worth of water every year. The U.S. Environmental Protection Agency (EPA), after conducting a national survey among U.S. water systems, recently found that the U.S. will need to invest about $138 billion to repair the water transportation infrastructure. According to EPA, the single largest category of need is the replacement of existing water distribution pipes - about $77 billion.

The Threat of Microbial Growth

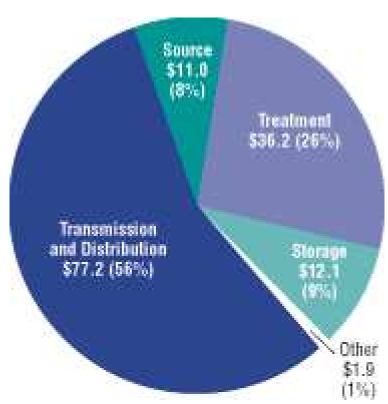
The threat of excessive microbial growth along the interior walls of drinking water distribution pipes is another health concern of water distribution officials. Biofouling -- the development of an organic bacterial community, also commonly known as biofilm -- is composed of microorganisms and their secretions. It is present in almost every water distribution system, and when uncontrolled may present a threat to public health.

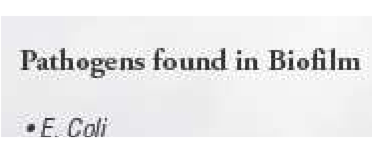
Biofilm are layers of bacteria that attach to the interior walls of water distribution pipes and to one another -- most heavily around corroded surfaces on pipes. The bacterial community traps nutrients, microbes, worms and waterborne pathogens to form an almost impenetrable material. Almost immediately after attaching itself to pipeline walls, the organism begins building upon itself, adding layer upon layer, forming a plaque-like coating. Such growth, together with tuberculation (corrosion encrustation), can clog water lines to the point of insufficient water pressure. This becomes a hazard for homes, businesses and even firefighters. In 1996, for example, a home that caught fire in Ontario was completely burned because the water-supply pipes were blocked with buildup, causing insufficient water pressure to extinguish the fire. In addition, biofilm contributes to further pipe corrosion and can deplete the chlorine used to disinfect drinking water and maintain water quality.

Without proper maintenance, excessive biofilm buildup, which can at times only be removed by scraping, can cause all sorts of other problems. During the summer of 1996 in Washington, D.C., and Boston, Mass., for instance, water supply officials found E. coli during routine sampling of the water distribution system, which remained present for some time after initial corrective measures were taken. D.C. health officials and EPA representatives cited biofilm as the primary cause of the contamination, while pledging to systematically replace or reline aging pipes.

Water Distribution Costs

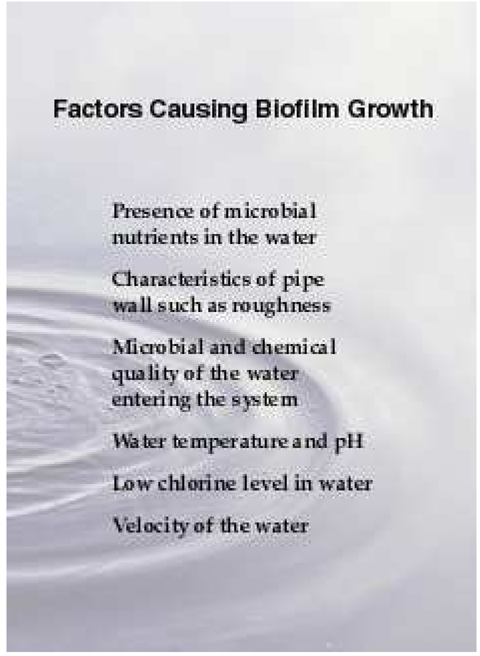
(in Billions of January '95 Dollars)





Chlorinating the drinking water supply is the method usually

used to control biofilm growth. In most cases, maintaining the normal amount of chlorine used to disinfect drinking water will control this problem. However, some water distribution systems, such as those in D.C. and Boston, have required special cleaning efforts. In both cases, water officials used remedies such as superchlorination (the process by which health officials apply increased chlorine levels to eliminate microbial growth) and/or high-velocity flushing on an intermittent basis. Depending on the amount of buildup, water suppliers may increase chlorine levels for a week or so to combat excess levels inside their water pipes.



In cases where the water is nutrient-rich and the biofilm has developed into a plaque-like coating, officials often have to flush the system with both increased chlorine levels and large amounts of water to flush away the biofilm. In extreme situations, officials implement more costly scouring programs which use mechanical devices, often referred to as "pigging," to remove biofilm growth.

Should none of these processes work, some officials suggest replacing or relining distribution pipes. When it is not necessary to replace an entire pipeline, contractors may install protective vinyl liners inside damaged pipes.

The Vinyl Pipe Solution

Because metallic water main materials are prone to rust and scale build-up, environmental and civil engineers working for municipal water utilities, sewer utilities and design engineering consulting firms have made vinyl the most often used pipe material today. On a linear basis, more vinyl pipe is currently being installed for buried water pipelines throughout the U.S. and Canada than the combined total of all alternative pipe materials. This widespread use is testimony to vinyl pipes' abilities to solve the more serious problems associated with operating and maintaining buried collection and distribution pipe networks.

Vinyl pipe, to some degree, is flexible -- a benefit other pipe materials do not have. This property provides a distinct advantage when pipes must be laid through unstable, shifting or heaving soils. Soil fluctuation can wreak havoc on just about anything in the ground that isn't both flexible and durable (in other words, immune to corrosion). Vinyl pipes are inherently inert to aggressive soil conditions and do not need the costly secondary internal protection found inside metallic pipes. Moreover, studies have shown that vinyl pipe breakage rates actually decline with age. In contrast to the much higher failure rates reported for other pipe materials, the failure rate documented for vinyl water pipes in Canada was only 0.7 per 100 kilometers of vinyl pipe.

Vinyl water mains also provide great resistance to biofilm formation. In fact, vinyl will not deteriorate or break down under attacks from bacteria or other microorganisms. Vinyl simply will not serve as a nutrient to bacteria growth the way most alternative pipeline materials do. And because vinyl pipe surfaces are smoother, water flows more easily than in metallic or cement-based pipes, enabling customers to save money on pumping costs.

The inherent durability, smoothness and installation ease afforded by vinyl pipes provide substantial benefits and help explain their appeal. Immune to both underground external corrosion and internal pipe corrosion, vinyl pipe can deliver water as clean and pure as it is received. The expanded use of vinyl pipe and the phasing out of other materials has the potential to slash annual maintenance and repair costs by 93 percent or more. And the potential savings range in the hundreds of millions of dollars per year.

Conclusion

Even with some of the safest water in the world, much of the water pipe infrastructure in the US and Canada suffers from serious deterioration. Recent events -- including waterborne disease outbreaks and extended "boil-water" notices in major cities -- have focused attention on the danger associated with contamination of public water supplies. Water contamination caused by fragile, aging pipelines and biofilm growth play a major role in water quality, maintenance and service interruptions, the need for costly infrastructure repairs and roadway and fire hazards.

Chlorine-based vinyl pipes and chlorine are proving to be key solutions to these expensive, health-threatening problems. Experts agree that chlorine's introduction early this century into drinking water systems is one of history's great public health advances. Vinyl -- with chlorine as a major building block -- is also proving to be an integral material in safely delivering water. It has increasingly gained popularity in today's underground water conveyance systems. These economical, strong, durable and easy to install pipes are giving water officials confidence that they can safely deliver safe water to their customers. In short, thanks to chlorine and chlorine-based vinyl pipes, more and more people are drinking safe water -- delivered safely.

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